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(54) **A fiber material of increased soluble dietary fibre and a process for its production.**

(57) A modified fibre material, preferably a legume or cereal grain fibre and most preferably a soy fibre material, which is characterized by an increased level of soluble dietary fibre and improved physical characteristics is produced by a process which comprises forming a slurry of a fibre material, typically a soy fibre such as the spent flake residue derived from soy isolate processing, and which typically has a relatively low percentage of soluble dietary fibre. In accordance with the present invention, the pH of the slurry is adjusted below about 4.5 by the addition of an edible acid. The slurry is then heated at a temperature and for a period of time sufficient to increase the soluble dietary fibre content, usually to a level of about 30% or greater of the total dietary fibre content in the case of soy fibre. Following modification, the modified fibre may be dewatered to provide a food ingredient that has improved textural properties as an additive to beverages, soups, creams, emulsified meats or other types of food products.

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The present invention relates to a modified fibre material, preferably a legume or cereal grain fibre and most preferably a soy fibre material, which is characterized by an increased level of soluble dietary fibre and improved physical characteristics.

Dietary fibre has long been recognized as an important ingredient in the human diet, and, as a consequence, a variety of food products have included a dietary fibre source as an added ingredient. The addition of a fibre source as an ingredient increases the total dietary fibre content of the food product to which it is added. The term "total dietary fibre" is generally intended to refer to both insoluble and soluble dietary fibre and represents the analytical value obtained by analysis by a procedure such as that set forth in the "Journal of the Association of Official Analytical Chemists" (hereinafter abbreviated "JAOAC") 75(3), page 395 (1992). Generally speaking, the term "insoluble dietary fibre" refers to the fibrous portion which consists of cellulose, lignin, and hemicellulose and which is generally non-soluble or non-swellable in water. The term "soluble dietary fibre" includes generally non-cellulosic polysaccharides, pectins, gums and mucilages, which are generally water-soluble or swellable. While the specific nutritional advantages of each type of fibre are not entirely known, a balance of soluble and insoluble dietary fibre is thought to be beneficial by many nutritionists. The fibre derived from cereals, and legumes in particular, is predominantly insoluble fibre. However, a high percentage of insoluble fibre represents a physical or textural problem when added to a foodstuff which requires a smooth or creamy texture. Insoluble fibre has a more gritty textural quality than does soluble fibre, and, in the case of beverages, also can give rise to a solubility or dispersibility problem. It would therefore be advantageous to be able to increase the soluble dietary fibre content of a dietary fibre source to improve the overall functionality or physical characteristics of the fibre material and provide a fibre source which could easily be added to beverages, soups, sour cream, emulsified meats or other similar types of products.

Legume or cereal grain fibre materials, and especially soy fibre materials, have generally been of two types: one which is derived exclusively from hulls; and a second which is the cellulosic or hemicellulosic material which generally surrounds the protein bodies in a soy material such as soy flakes, which is made from defatted and dehulled soybeans. This latter fibrous or cellulosic fraction generally remains behind in a conventional process for the production of a soy protein isolate which involves the dispersal of the soy flakes in an aqueous medium and adjustment of the pH by the addition of an alkali. The protein is substantially solubilized in the aqueous solution and the insoluble residue is composed of the cellulosic and hemicellulosic materials which are not alkali-soluble. These insoluble solids are often referred to as the "spent flake residue". This insoluble fraction is then cleaned and dried to provide a soy dietary fibre material which has a relatively high insoluble dietary fibre content and a relatively low soluble dietary fibre content. For example, this material may typically have a total dietary fibre content which exceeds 70% by weight, of which about 90% or more is insoluble dietary fibre and 10% or less is soluble dietary fibre.

We have now discovered a process for producing a fibre material of increased soluble dietary fibre content, especially from a legume or cereal grain fibre material, and which may also have improved physical or textural characteristics.

Thus, the present invention consists in a process for preparing a fibre material having an increased soluble dietary fibre content in which an aqueous slurry of an edible fibre material is adjusted to a pH of below about 4.5 and the pH adjusted slurry is heated for a temperature and a time sufficient to increase the soluble dietary fibre content of the fibre material.

In the process of the present invention, a fibre material of increased water soluble dietary fibre content may be prepared by forming an aqueous slurry of a fibre material, preferably a legume or cereal grain fibre material and most preferably a soy fibre material, such as the "spent flake residue" which represents the insoluble fibrous residue that remains following substantial extraction of the protein from soy flakes. The pH of the slurry is then adjusted to a pH of below about 4.5 and preferably below about 3.5 by the addition of an acid, which would normally and preferably be an edible acid. The slurry is then heated at a temperature and for a time sufficient to increase the soluble dietary fibre content of the fibre material. The pH, temperature and time are interrelated to the extent that a lower pH may require a lower heating temperature whereas a higher pH may require a higher temperature and, in each situation, the time of heating may vary from a few seconds at a higher temperature to about 16-18 hours at room temperature. For example, in general terms, we prefer heating for a period of a few seconds at about 310°F to a period of from 16 to 18 hours at room temperature. These conditions significantly increase the soluble dietary fibre content, for example, from a level of below 10% of the total dietary fibre content to a level of at least about 30% or higher of the total dietary fibre content in the case of soy fibre. The resulting modified fibre, when in a liquid, has a much higher viscosity and improved physical characteristics which make the modified fibre readily suspendable in aqueous media such as beverages with a very smooth and creamy mouthfeel. This unexpected improvement in physical characteristics overcomes many of the textural problems with the use of legume fibre material because of the relatively high level of insoluble dietary fibre that is normally found in fibre of this type. Following acidification and heating, the

modified fibre material can be dewatered, preferably by spray drying, to provide a dried food ingredient that, upon rewetting in an aqueous medium, retains the high viscosity and desirable physical characteristics which were achieved prior to dewatering. These improved physical characteristics are retained even if the acidified material is neutralized prior to dewatering.

As an example, a soy fibre material prior to modification may have a total dietary fibre content of about 80% by weight of the fibre product, of which about 95% of the total dietary fibre content is commonly insoluble dietary fibre and only about 5% of the total dietary fibre content is soluble dietary fibre. By the same token the density of the unmodified soy fibre material is usually about 10 lb./cu.ft. and an aqueous slurry of the material has a viscosity at 4% solids and room temperature of about 20 centipoise. Following modification pursuant to the present invention, the modified soy fibre material will normally still have a total dietary fibre content of about 80% by weight of the soy fibre material, however, about 50% of the total dietary fibre content can be expected to be insoluble dietary fibre while approximately 50% of the total dietary fibre content of the soy fibre material will now be soluble dietary fibre. Furthermore, following modification, the viscosity of a 4% aqueous slurry at room temperature will now be approximately 12,000 centipoise, which represents a dramatic and significant increase in viscosity. The viscosity of the slurry of modified soy fibre material will vary depending on the conditions for modification since the modification of the soy fibre pursuant to the present invention results in a significant increase in viscosity early in the reaction which will later diminish.

The fibre material which is used as the starting material for the process of the present invention is preferably an edible material and can be selected from various legume fibres, such as soy and pea fibre, derived from the hulls or cotyledons of the legumes as well as various cereal grain fibres, such as corn bran and the like. Most preferably, the starting material comprises the "soy spent flake residue" or the fibrous fraction which remains following substantial extraction of the protein such as would occur during a conventional process for the production of an isolated soy protein. A typical starting material which may be used for the soy isolate process are soy flakes which are derived from soybeans which have been dehulled. These soy flakes are also preferably defatted, for example by the use of a solvent, such as hexane or alcohol, prior to being used in the isolate process.

The spent flake residue from which the protein is substantially removed is typically treated prior to processing to improve the whiteness by the removal of debris or other materials that may have been inadvertently included in the starting material. A typical and preferred process for removal of any extraneous material from the spent flake residue is further described in British Patent No. 2,020,666. The preferred soy fibre material for use in the process of the present invention has a protein content on a dry basis of about 14%, an ash content of about 4% by weight on a dry basis, a density of about 15lb./cu. ft. and a slurry viscosity at 4% solids and room temperature of about 20 centipoise.

In accordance with the present invention, the fibre material, such as the soy spent flake residue, which may have been dewatered or may be used in a wet state, is then formed into an aqueous slurry. This preferably has the maximum solids level which can be employed for ease of processing. In any event, it preferably has a solids level of at least about 4% by weight and more preferably from 7 to 14% by weight.

The aqueous slurry, e.g. of the legume fibre material or spent flake residue, is then adjusted to a pH below about 4.5 and preferably below about 3.5, normally by the addition of an edible acid. A preferred range is from pH 1.0 to pH 4.5. A most preferred range for pH is between about 2.0 and 3.0. The edible acid that is used for acidification is not critical to the present invention and may be selected from a wide variety of acids commonly used for this purpose including phosphoric and hydrochloric acids.

Following adjustment of the pH of the slurry of fibre material, the slurry is then heated for a time and temperature sufficient to modify the physical characteristics of the fibre material and increase the soluble dietary fibre content. Preferably, it increases the soluble dietary fibre content from below about 10% by weight to at least about 30% by weight or more of the total dietary fibre content in the case of a soy fibre material. In fact, it is not uncommon to achieve a soluble dietary fibre content of about 50% or more of the total dietary fibre content of the starting material in the case of a soy fibre. In the case of pea hulls, or cereal grain fibres the soluble dietary fibre content may be increased only from about 5 to 20% or more of the total dietary fibre content of the hulls. In the case of pea fibre derived from pea cotyledons, the increase is at least as much as is achieved with soy spent flake residue.

The time and temperature of heating is may vary over an extremely wide range, for example from a few seconds at a relatively high temperature to overnight (12 - 16 hours) at room temperature depending on the pH. Preferred times and temperature are from 180 to 310°F from about a few seconds to about 30 minutes for the preferred pH range.

Following heat treatment and modification of the fibre material, the modified fibre is then preferably neutralized and dewatered. Although neutralization is not essential, nevertheless it is desirable for ease of processing and flavour. Preferably the pH of the modified fibre material is adjusted to about 7.0, for example by

the addition of an edible alkali such as sodium hydroxide. Although the exact means used for dewatering of the modified soy fibre material is not critical it is preferred to spray-dry the material in order to dewater and the exact conditions including time and temperature for spray drying are conventional and well known to those skilled in the art.

The modified fibre, and preferably the modified soy fibre material, following dewatering may be used in a variety of food products as an added ingredient and as a source of dietary fibre. Because the soluble dietary fibre content of the material has been so dramatically increased as well as the physical characteristics, the modified fibre material of the present invention is very well suited for addition to food products in which a gritty texture will normally detract from the appearance and texture of the food product. Typical products to which the modified fibre material of the present invention may be added include beverages, such as juices, milks, sour cream, frozen dessert, soup, and emulsified meats such as hot dogs. The product is also suitable for other types of food applications such as baked goods and the like. Many other types of food applications are also possible because of the modified physical characteristics and the increased soluble dietary fibre content of the modified fibre material of the present invention.

The following Examples describe specific but non-limiting embodiments of the present invention.

EXAMPLE 1

1710 lb. of an aqueous slurry of spent flake residue having a total solids level of 7.5% by weight and a pH of 8.98 was cleaned as described in British Patent 2,020,666. 200 lb. of the cleaned slurry were adjusted to a pH of 7.0 by the addition of 175 ml. of concentrated aqueous hydrochloric acid. This pH adjusted slurry was then sterilized by jet cooking at a temperature of about 305°F for a retention time of about 9 seconds. The slurry was then spray-dried at an exhaust temperature of 200°F. This portion was designated as an untreated control sample.

A second portion of 1510 lb. of the slurry of spent flake residue was then adjusted to a pH of 4.0 by the addition of 1160 ml. of concentrated hydrochloric acid. The pH adjusted slurry had a total solids level of 6.9% by weight. The slurry was then heated by the addition of steam to a temperature of about 180°F for 30 minutes. 200 lb. of the heated slurry was then sterilized and spray-dried as described above. This was designated as Sample 2. The other 200 lb. portion was first neutralized to a pH of about 7.0 by the addition of a 50% solution of sodium hydroxide and then jet cooked and spray-dried as described above. This was designated as Sample 3.

An 1100 lb. portion of the pH 4.0 aqueous slurry of spent flake residue was adjusted to a pH of 2.5 by the addition of concentrated hydrochloric acid. A 200 lb. portion of the slurry was sterilized in a jet cooker and spray-dried at the conditions described above. This was designated as Sample 4. Another 200 lb. portion was heated to a temperature of 180°F for 30 minutes, then jet cooked and spray-dried under the conditions described above. This was designated as Sample 5.

Another 200 lb. portion of the slurry at a pH of 2.5 was also heated to 180°F for 30 minutes by the addition of steam, then neutralized to a pH of about 7.0 by the addition of a 50% solution of sodium hydroxide then jet cooked and spray-dried as generally described above. This was designated as Sample 6.

A 200 lb. portion of the slurry at a pH of 2.5 was heated at a temperature of 180°F for about 30 minutes by the addition of steam, neutralized to a pH of about 7.0 by the addition of 50% sodium hydroxide solution and then spray-dried as described above. This was designated as Sample 7.

All of the samples including the control were evaluated and analyzed for total dietary fibre, insoluble dietary fibre, soluble dietary fibre by the procedures described in the JAOAC 75(3), p. 395 (1992).

The samples were also analyzed for protein, moisture, ash, density and viscosity at 4% solids and room temperature. The results are set forth in Table 1 below and the analytical values are expressed on a dry basis of the product.

TABLE 1

Sample	Process pH	Moisture (%)	Protein (% dry basis)	Ash 800°C
Control	7.0	5.65	12.5	1.10
2	4.0	8.68	12.8	1.86
3	4.0	5.54	13.4	2.23
4	2.5	5.65	13.6	<0.2
5	2.5	5.57	13.4	1.47
6	2.5	6.15	12.8	4.50
7	2.5	5.98	12.8	4.67

TABLE 1 (cont.)

	Dietary Fibre (% dry basis)			Density	(CPS)
Sample	Insoluble	Soluble	Total	(lb./ft. 3)	Viscosity
Control	78.3	4.7	83.0	10.9	12.5
2	75.9	7.4	83.3	15.4	32.6
3	76.9	2.1	79.0	11.1	13.1
4	27.5	41.6	69.1	25.4	13,100
5	26.3	42.5	68.8	25.8	12,900
6	37.8	39.1	76.9	28.0	17,000
7	37.6	39.8	77.4	27.1	12,300

It may be seen from the results that the samples which were treated at a pH of 2.5 had a substantially increased soluble dietary fibre level with a significantly increased viscosity and density.

EXAMPLE 2

1030 lb. of cleaned spent flake residue as described in Example 1 having a total solids level of 6.3-7.2% by weight was split into seven separate portions and then each of these separate portions was designated as samples A-G and jet cooked at the pH, temperature and for the retention time set forth in Table 2 below. Each of the samples following jet cooking was neutralized to a pH of about 7 by the addition of a 50% solution of sodium hydroxide and then spray-dried at an exhaust temperature of 200°F. Each of the treated samples were analyzed for total dietary fibre, insoluble dietary fibre and soluble dietary fibre as described in Example 1. Each

sample was also analyzed for moisture, ash, protein and viscosity (2% solids) measured as described in Example 1. The results of this analysis including process conditions are described in Table 2 below.

TABLE 2

	Process Conditions			
		Jet Cooker		
Sample	Slurry pH	Temp. (°C)	Time (sec)	Moisture (%)
A	3.0	250	9	5.67
B	3.0	250	23	5.60
C	3.0	305	23	5.89
D	3.8	250	23	5.30
E	3.8	305	23	5.71
F	4.5	250	23	5.20
G	4.5	305	23	5.40

TABLE 2 (cont.)

			Dietary Fibre, % dry basis			(cps)
Sample	Protein	Ash	Insoluble	Soluble	Total	Viscosity
A	11.7	4.58	59.4	18.6	77.9	6
B	11.8	4.83	55.7	21.7	77.4	8
C	12.6	5.30	34.5	45.5	80.0	121
D	11.9	3.98	64.8	10.8	75.6	5
E	12.6	4.50	39.3	42.1	81.4	122
F	12.3	3.28	64.1	17.7	81.9	4
G	13.0	3.65	50.5	29.6	80.1	21

The results indicate that the reaction to increase soluble dietary fibre to above about 30% by weight is dependent on pH, time, and temperature to the extent that the lower the pH is, the less heating is required, in terms of time and temperature, whereas the higher the pH is, the more heating is required in terms of time and temperature.

EXAMPLE 3

A portion of an aqueous slurry of soy spent flake residue having a pH of about 6.9 and a total solids content of 4% by weight was split into 300 ml. portions which was then adjusted to the process pH indicated in Table 3 below by the addition of concentrated hydrochloric acid. Each slurry was then heated to the indicated temperature and held at that temperature for the indicated period of time. Following heating each 300 ml portion was neutralized to a pH of about 7 by the addition of a 50% aqueous solution of sodium hydroxide. Each sample was then analyzed for total, insoluble, and soluble dietary fibre as described in Example 1. Viscosity of each sample was measured at 4% solids and room temperature. Evaluation of a control sample was made at the same time. The results of this testing is set forth in Table 3 below.

TABLE 3

Sample	Process pH	Process Temp.	Process Time
Control	7.0	-	-
1	1.0	RT	Overnight
2	2.0	RT	Overnight
3	3.0	RT	Overnight
4	4.0	RT	Overnight
5	2.0	140°F	30 min.
6	3.0	140°F	30 min.
7	2.0	140°F	Overnight
8	3.0	140°F	Overnight
9	4.0	140°F	30 min.
10	4.0	140°F	Overnight
11	3.5	180°F	30 min.
12	4.0	180°F	30 min.
13	4.5	180°F	30 min.
14	3.5	180°F	Overnight
15	4.0	180°F	Overnight
16	4.5	180°F	Overnight

TABLE 3 (cont.)

Sample	% Dietary Fibre, dry basis Insoluble	Soluble	Total	(cps) Viscosity
Control	90.0	13.8	104	18
1	32.0	48.5	81.2	371
2	51.8	19.2	71.0	20
3	59.0	12.5	71.5	22
4	53.5	27.3	80.8	19
5	35.8	45.5	81.3	735
6	54.8	13.0	67.5	37
7	25.8	47.0	72.8	407
8	47.0	24.8	71.8	22
9	58.8	18.5	77.3	25
10	63.8	<12.5	-	17
11	76.0	<12.5	-	16
12	82.8	<12.5	-	15
13	75.2	<12.5	-	15
14	28.0	41.8	69.8	50
15	62.8	<12.5	-	25
16	65.8	19.8	85.8	21

The above results indicate that the soluble dietary fibre can be substantially increased even at room temperature, provided that the pH is low enough.

EXAMPLE 4

A pea fibre identified as "Hi Fi Lite" produced by Woodstone Foods Ltd., 1445 Church Avenue, Winnipeg, Manitaba, R2X 2X9, Canada, was formed into an aqueous slurry at 5% total solids. The slurry was split into two portions, the first portion was adjusted to a pH 2.0 by the addition of concentrated hydrochloric acid, and the second portion was adjusted to a pH of 1.0 by the addition of concentrated hydrochloric acid. Each of the pH adjusted samples were held overnight at 180°F. Following heating, the two heated samples were analyzed for total dietary fibre, including soluble and insoluble fibre by the procedure listed in Example 1, along with an untreated control. The analysis results are listed in Table 4.

TABLE 4

	INSOLUBLE FIBRE	SOLUBLE FIBRE	TOTAL
Control	74.7	3.6	78.2
pH 2.0	46.9	15.7	62.6
pH 1.0	40.4	13.1	53.5

It may be seen that the soluble dietary fibre has been significantly increased by the acid treatment as described in the present invention.

EXAMPLE 5

A pea fibre described as being made from dehulled peas and identified as "Grinsted P-FIBRE 150" produced by Grinsted Products, Inc., 201 Industrial Parkway, Topeka, Kansas 66031, was formed into an aqueous slurry at 5% total solids. The slurry was split into two portions, the first portion was adjusted to a pH of 2.0 by the addition of concentrated hydrochloric acid, and the second portion was adjusted to a pH of 1.0 by the addition of concentrated hydrochloric acid. Each of the pH adjusted samples were held overnight at 180°F.

Following heating, the two treated samples were analyzed for total dietary fibre, along with an untreated control sample, including soluble and insoluble dietary fibre by the procedure listed in Example 1. The analysis results are listed in Table 5.

TABLE 5

	Insoluble Fibre	Soluble Fibre	Total
Control	38.9	5.6	44.5
pH 2.0	13.9	14.3	28.2
pH 1.0	13.0	10.4	23.4

The soluble dietary fibre has been significantly increased by the procedure of the present invention.

EXAMPLE 6

A corn bran identified as "Bestbran" 90 G-ultrafine refined corn bran, produced by A. E. Staley, Decatur, Illinois, was formed into an aqueous slurry at 10% total solids, split into two portions as described in Example 5. The portions were treated as described in Example 5. The two treated samples, along with an untreated control, were analyzed for total dietary fibre, including soluble and insoluble dietary fibre by the procedure listed in Example 1. The results are listed in Table 6.

TABLE 6

	Insoluble Fibre	Soluble Fibre	Total
Control	91.0	1.4	92.4
pH 2.0	48.5	19.0	67.5
pH 1.0	29.9	<6.2	--.--

The results show an increase in soluble dietary fibre by the process of the present invention.

Claims

1. A process for preparing a fibre material having an increased soluble dietary fibre content in which an aqu-

eous slurry of an edible fibre material is adjusted to a pH of below about 4.5 and the pH adjusted slurry is heated for a temperature and a time sufficient to increase the soluble dietary fibre content of the fibre material.

2. A method according to Claim 1, in which the aqueous slurry is formed at a solids level of at least 4% by weight.

3. A method according to Claim 2, in which said aqueous slurry is formed at a solids level of from 7 to 14% by weight.

4. A method according to any one of Claims 1 to 3, in which said fibre is a legume fibre or a cereal grain fibre.

5. A method according to Claim 4, in which the fibre material is a soy fibre material.

6. A method according to Claim 5, in which the soy fibre material is the spent flake residue which remains following substantial extraction of the protein from soy flakes.

7. A method according to any one of Claims 1 to 6, which includes the additional step of dewatering the fibre material after heating.

8. A method according to Claim 7, in which the dewatering is carried out by spray drying.

9. A method according to any one of Claims 1 to 8, in which the pH of the slurry is adjusted to below about 3.5.

10. A method according to any one of Claims 1 to 8, in which the pH of the slurry is adjusted to between about 1.0 and 4.5.

11. A method according to Claim 10, in which the pH of the slurry is adjusted to between about 2.0 and 3.0

12. A method according to any one of Claims 1 to 11, in which the time and temperature is between a few seconds at about 310°F, and from 16 to 20 hours at room temperature.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 30 8190

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	EP-A-0 421 758 (MICHIGAN BIOTECHNOLOGY) * page 13, line 16 - line 25; claims 3-10; table 6 * ---	1-12	A23L1/308 A23L1/20 A23L1/10
X	EP-A-0 474 230 (TERUMO) * page 1, line 1-6; claims * * page 4, line 36 - line 40 * * page 5, line 4-6 * * page 5, line 40 - line 44 * ---	1-12	
A	EP-A-0 112 621 (TOKIWA KANPO PHARMACEUTICAL) * claims * ---	1-12	
A	EP-A-0 194 060 (NIHON SHOKUKIN KAKO) * page 6, line 11 - line 20; claims 1-4,8,9 * -----	1-12	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			A23L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25 January 1994	Van Moer, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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